Intramedullary Nailing of Tibial Fractures. Is There a Relationship Between the Entry Point and Its Final Alignment?

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ABSTRACT

Introduction: Tibial fractures represent approximately 2% of adult fractures. Today, intramedullary nailing is the procedure of choice to treat diaphyseal fractures of the tibia; however, this technique is not exempt from complications, misalignment in the coronal plane is one of the most frequent and feared by surgeons. The aim of this study was to investigate the relationship between nail entry point and misalignment in the coronal plane after surgery. **Materials and Methods:** We carried out a retrospective, descriptive, observational study between January 2015 and January 2019 of patients with diaphyseal fractures of the tibia, treated with intramedullary nailing. Radiographs were obtained in the immediate postoperative period and then every two months. The eighth-month radiograph, in which clear signs of bone consolidation could be observed, was taken into account to assess tibial alignment. **Results:** When the nail entry point was central, there was only a 0.021 chance (or 2.1%) of any significant misalignment in the immediate postoperative period and after 8 months. In contrast, when it was medial, the chances of a valgus tendency were >0.85 (or 85%) already at the first image, i.e., post-surgery; and when it was lateral, this possibility was modified and deepened according to the time elapsed until the image achieved in the patient. **Conclusion:** A marked and continuous relationship was observed between the entry point of the intramedullary nail and the alignment of the tibia after bone consolidation.

Keywords: Intramedullary nailing; tibia; misalignment.
Level of Evidence: IV

Enclavado endomedular en fracturas de tibia. ¿Existe una relación entre el punto de entrada para la inserción del clavo y su alineación final?

RESUMEN

Introducción: Las fracturas de tibia representan aproximadamente el 2% de las fracturas del adulto. El enclavado endomedular es hoy el procedimiento de elección para tratar fracturas diafisarias de tibia; sin embargo, esta técnica no está exenta de complicaciones, la desalineación en el plano coronal es una de las más frecuentes y temidas por los cirujanos. El objetivo de este estudio fue investigar la relación entre el punto de entrada del clavo y la desalineación en el plano coronal después de la cirugía. **Materiales y Métodos:** Se realizó un estudio retrospectivo, descriptivo, observacional, entre enero de 2015 y enero de 2019, de pacientes con fracturas diafisarias de tibia, tratadas con clavo endomedular. Se obtuvieron radiografías en el posquirúrgico inmediato y luego cada dos meses, se tuvo en cuenta la radiografía del octavo mes, en la que se observaban signos francos de consolidación ósea, para valorar la alineación tibial. **Resultados:** Cuando el punto de entrada del clavo fue central, hubo apenas un 0,021 de posibilidades (o 2,1%) de alguna desalineación significativa en el posquirúrgico inmediato y luego de 8 meses. En cambio, cuando fue medial, las posibilidades de una tendencia al valgo fueron >0,85 (u 85%) ya al tomar la primera imagen, i.e., poscirugía; y cuando fue lateral, esta posibilidad se modifica y profundiza según el tiempo transcurrido hasta la imagen lograda en el paciente. **Conclusión:** Se observó una relación marcada y continua entre el punto de entrada del clavo endomedular y la alineación de la tibia después de la consolidación ósea.

Palabras clave: Enclavado endomedular; tibia; deseje.
Nivel de Evidencia: IV

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INTRODUCTION

Tibial fractures account for approximately 2% of fractures in adults.[1,2] High-energy trauma, traffic accidents, and sports accidents are the most common causes in young adults, and low-energy trauma and falls from their own height are the most common causes in the elderly.

Nowadays, intramedullary nailing is the procedure of choice to treat tibial shaft fractures, because it is a minimally invasive technique that avoids additional soft tissue trauma. Conservative management of these fractures has often resulted in nonunion, rotational deformity, or stiffness of the adjacent joints, so there has been a shift toward surgical management of these fractures in recent times. However, the optimal surgical approach to treat these fractures remains debatable. Options include intramedullary implants, external fixation, plate fixation, or a combination of these techniques. In recent years, closed reduction with minimally invasive plates and locked intramedullary nailing have become widely used therapeutic modalities for fractures of the proximal and distal tibial metaphysis. In numerous studies, a superior outcome was observed after intramedullary nailing. However, this surgical technique is not exempt from complications.[3,4] Misalignment in the coronal plane is one of the most frequent and feared by surgeons.[5,6] Different nail entry points have been studied to avoid this complication and prevent varus or valgus deviation.[7,8]

The objective of this study was to investigate the relationship between the entry point of the nail and the final alignment after surgery in adult patients with tibial shaft fractures that had undergone surgery at our institution.

MATERIALS AND METHODS

We carried out a retrospective, descriptive, observational study, approved by the ethics committee of our institution, which included all patients who had suffered a tibial shaft fracture treated with intramedullary nailing between January 2015 and January 2019. All surgeries had been carried out by orthopedic surgeons trained in orthopedic trauma.

The inclusion criteria were: patients with tibial shaft fractures, with intra-articular extension or without extension, with skeletal maturity, and who had undergone definitive treatment with an intramedullary nail. We included 42 A-B-C fractures according to the OTA/AO classification.

Additional exclusion criteria were patients with preexisting ankle arthrodesis, initial amputation, and follow-up <12 months.

A serial radiographic control was performed in the immediate postoperative period, at 4 weeks, and then at 2, 4, and 8 months after the intervention. A fracture was considered to have consolidated if a minimum of three bony bridges were observed in the anteroposterior and lateral projections. The presence of delayed consolidation was also evaluated, that is, the lack of clear signs of osseous consolidation at 3-6 months after surgery. These images were collected using the Picture Archiving and Communication System (Kodak Carestream PACS, Kodak Company). Normal alignment was determined between 5° varus and 5° valgus.

All patients followed a similar postoperative protocol consisting of early range of motion and weight bearing based on pain tolerance.

Surgical technique

Patient positioning

The patient was placed in the supine position. The knee of the leg to be operated on was flexed at 90-110°, to maintain this angle a carbon fiber triangle was used below the knee. A pillow was placed under the glute of that leg in order to neutralize the external rotation tendency of the limb by tilting the hemipelvis.

Approach

Through a transpatellar approach, the infrapatellar fat pad was released, exposing the anterior edge of the tibial plateau, where the entry point of the nail was located. The entry point was centered on the medullary canal, this was controlled by intraoperative radioscopy.

Fracture reduction

After the approach, we performed a fluoroscopy-guided reduction of the fracture; this can be done by various methods, such as manual traction, distractors, joystick, or by opening the fracture site for direct reduction. In our case, we used manual traction on the tibial axis.

Creation of the medullary canal

Once the entry point of the nail was located, the medullary canal was created using a metal guide which was then advanced through the canal; at this stage, a soft tissue protector was used to minimize soft tissue damage. All these steps were guided by fluoroscopy.

Reaming

We inserted the cannulated flexible drill bit over the guide wire. We reamed sequentially from the smallest to the largest diameters, with 0.5mm increments. The reaming should be 0.5 to 1.5 mm larger than the nail diameter, since the medullary canal is not a perfectly straight structure.

Intramedullary nail placement

After drilling and measuring the length of the implant, the definitive nail was placed. The distal lock was performed first and then the proximal, always guided by fluoroscopy. The stability of the fracture was examined; then, both the main approach and the locks (two proximal and two distal) were closed by planes.

In the immediate postoperative radiograph, the entry point of the intramedullary nail was observed, which was classified as: central, medial, and lateral (Figure 1), taking both tibial spines as radiographic references.

Figure 1. Intramedullary nail entry points. **A.** Center. **B.** Medial. **C.** Lateral.

For this procedure, a straight vertical line was drawn from the midpoint of the tibial spines to the distal end of the tibia, above the tibiotalar joint (Figure 2); then, the deviation of the fracture was observed and it was classified as varus, valgus, or neutral. This assessment was made by drawing a straight line from the tibial spines to the center of the tibial diaphysis and then another straight line from this last point to the distal end of the tibia without taking into account, in this time, the degrees of misalignment.

Radiographic controls were performed every two months to detect if there was a delay in consolidation.

Eight months after surgery and with the fractures already consolidated, the measurement was performed again to assess the alignment of the fracture, in the same way as in the immediate postoperative period. On this occasion, we took into account the degrees of misalignment of the fracture in the coronal plane, classified as: varus, valgus, and neutral (Figures 3-5).

Figure 2. Methodology for measuring the coronal axis of the tibia for the classification of the entry point of the intramedullary nail.

Figure 3. Tibial fracture, post-placement of the intramedullary nail, without deviation in the coronal axis. **A.** 177.74°. **B.** 179.21°.

Figure 4. Varus deviation of the tibia, post-placement of the intramedullary nail, with a lateral entry point. **A.** 174.38°. **B.** 168.54°.

Figure 5. Valgus deviation of the tibia, post-fracture and intramedullary nailing with a medial entry point. **A.** 179.15°. **B.** 173.80°.

RESULTS

The sample consisted of 77 patients (74% men), representing two different age strata (p = 0.0096) with 95% confidence intervals [40.3; 59.6] and [31.9; 41.7] years, for women and men, respectively, this shows that the age representation of the study is concentrated around 37 years. On the other hand, age was not associated with the selection of the entry point of the intramedullary nail (p = 0.832), nor with the assessments of the positions reported by the immediate postoperative images (p = 0.547) and after 8 months (p = 0.868). This aspect is shown in Figure 6.

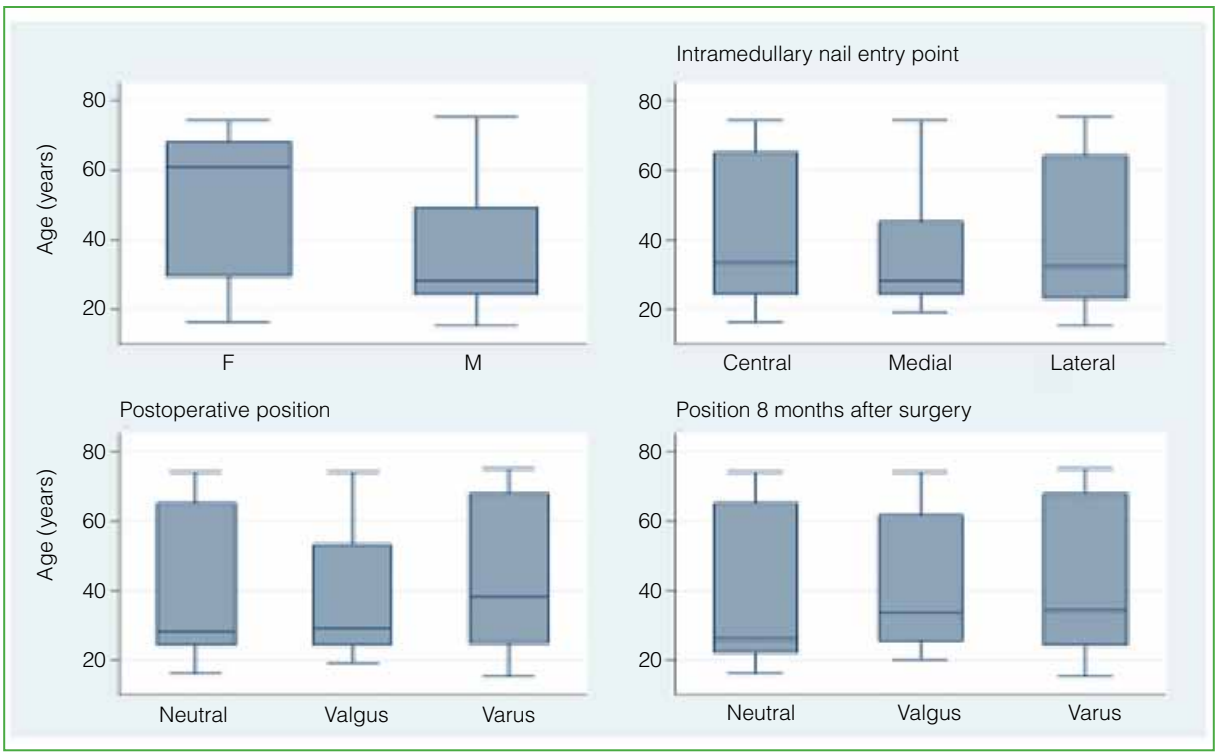

Figure 6. Box-plot for patient age by sex (upper left), entry point (upper right), postoperative nail position (lower left), and postoperative nail position after 8 months (lower right), 2015-2019.

The nail entry point was not randomly selected in the different fracture classifications (p = 0.012, Figure 7, upper right); for example, only 6% of the 54 surgeries for 42 A fractures, and 67% of the 42 B fractures, had a medial entry point.

Considering the entry point of the intramedullary nail (central, medial, or lateral), after surgery, the radiograph indicates that, except for the former (central), the remaining positions suffered significant misalignment (p = 0.002 and p = 0.0011 for medial and lateral, respectively). Indeed, in 87% of patients who received the nail in the central position, it was also central (i.e., neutral) after surgery. In contrast, of those who received the nail in the medial position, only 3.5% remained in the original position, with 93% reporting a misalignment or valgus tendency, while in all patients with lateral entry, misalignment in the coronal plane was observed in the postsurgical radiographs, and 84% of these presented misalignment or varus tendency. This behavior was only attenuated when the fracture classification (AO) was 42C, being homogeneous in the rest (42A and 42B, p = 0.634).

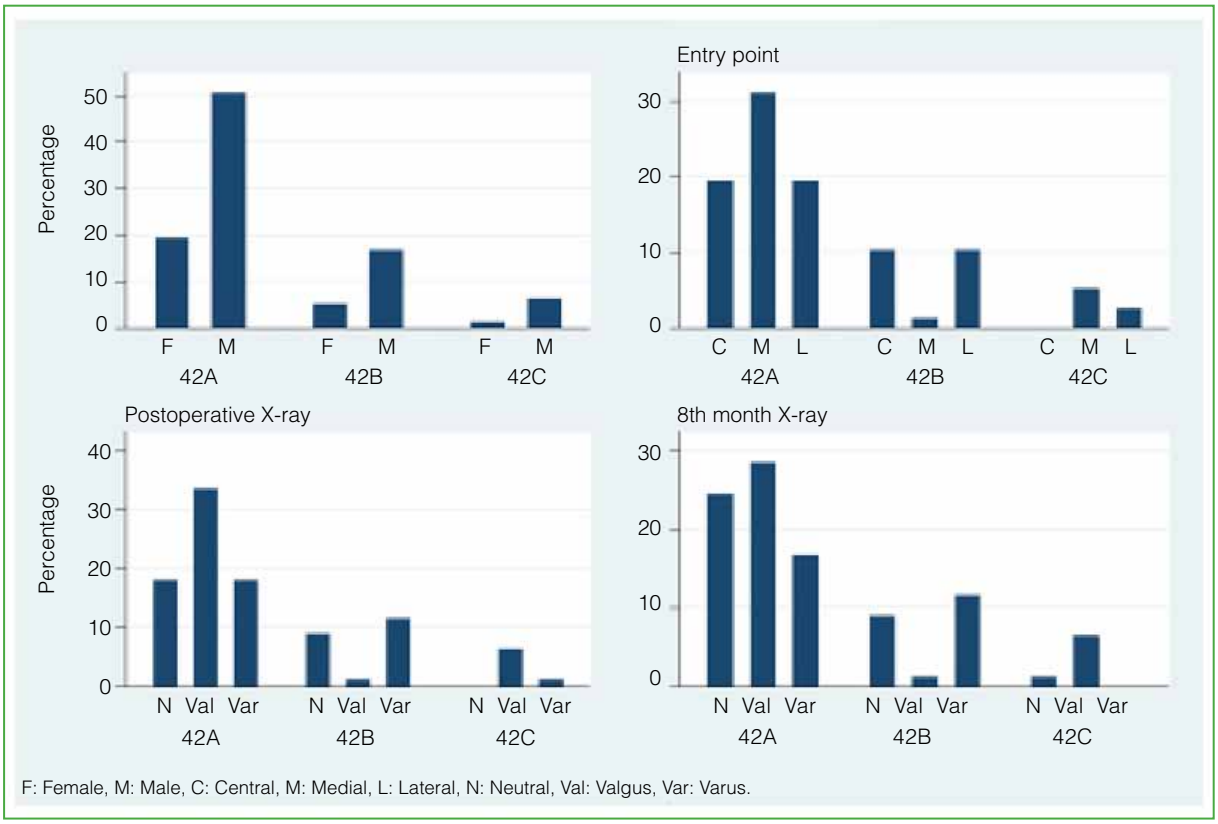

Figure 7. Patient frequency distributions based on fracture classification and gender (upper left), intramedullary nail entry point (upper right), post-surgery alignment assessment (lower left), and after 8 months (lower right), 2015-2019.

Eight months after surgery, the radiographic assessment showed partial agreement (overall adherence 81%) with the one made immediately after surgery; that is, although most central ones remained in that position (87% of patients) and medial ones had a tendency to valgus misalignment (73%), seven patients from the latter group (24%) maintained their original position. Figure 2 globally illustrates this behavior.

Finally, looking at the immediate postoperative radiographs, as well as the eight-month control radiograph, when the nail entry point was central, there was only a 0.021 chance (or 2.1%) of any significant misalignment in the postoperative period and after eight months. In contrast, when the entry point was medial, the chances of presenting a valgus tendency were greater than 0.85 (or 85%) already at the time of taking the first postoperative radiograph. When the entry point of the intramedullary nail was lateral, this chance was modified and deepened according to the time elapsed until the final radiographic image achieved in the patient.

In summary, in a population such as the one who attended our institution in the mentioned period to achieve a satisfactory alignment, the entry point must be central, regardless of the patient's age and the fracture type or classification.

DISCUSSION

Tibial shaft fractures represent around 5-11% of all tibial fractures.[9] The locked intramedullary nail is the accepted primary treatment for this type of fracture,[10-14] and is the treatment of choice in most of the literature reviewed, as well as in our study, because it is a minimally invasive procedure, with less soft tissue damage, and fewer post-surgical complications. Krishan et al.[15] showed a satisfactory angular alignment for tibial shaft fractures treated with intramedullary nailing. In our study, 35% of the patients treated with this method obtained a

neutral radiographic alignment eight months after surgery, without misalignment in the coronal plane, this was what the orthopedic surgeons expected when they planned the surgery, while Nork et al.[16] reported an acceptable radiographic alignment, with an angle <5° in any plane, in 92% of metaphyseal tibial fractures treated with intramedullary nailing. Kruppa et al.[17] reported a lower percentage of correct alignment and acceptable coronal plane angulation, within the defined 5° norm, in 76% of intramedullary nail fractures. Fracture malalignment in the coronal plane is a fairly common complication of intramedullary nailing of tibial shaft fractures, as shown by Franke et al.[18] In our study, it was the main postoperative complication, given that 65% of our patients experienced some degree of misalignment, either varus or valgus, although it should be noted that many of these cases were radiographic findings in postoperative controls, without causing symptoms or discomfort in the patients. Kruppa et al.[17] reported that most of the misalignments had a valgus tendency, information that is reflected again in our analysis, since 33.8% of our cases had a valgus misalignment, compared to 31.2 % of varus misalignment. Weninger et al.[19] showed that the degree of frontal plane malalignment depended on the location of the nail entry on the tibial plateau, as well as that lateral nail insertion led to varus malalignment in a significant number of patients. In our study, we agreed with the latter, since we observed a marked relationship between the entry point of the intramedullary nail and its posterior alignment. It was shown that patients with central entry points had less possibility of some misalignment; furthermore, all patients with a lateral entry point developed misalignment in the coronal plane, the most frequent being varus misalignment, as reported by Weninger et al.[19] However, 25% of our cases with a medial entry point and a valgus malalignment on immediate post-surgical radiographs were corrected and we observed an acceptable angle <5° in all planes eight months after implant placement, an important situation that is extremely useful at the time to carry out the procedure and on which there is not much literature.

In an anatomical study, Lembcke et al.[8] found a varus malalignment caused by a lateral and valgus entry point after medial nail insertion. This result was similar to that of our analysis, because we found a direct relationship between a lateral entry point (32.5%) and varus deviation (31.2%), as well as between valgus deviation (33.8%) and a medial entry point (36.4%).

In the already mentioned study by Weninger et al.,[19] it was observed that valgus misalignment decreases if the intramedullary nails have a central entry point, and also that surgeons should take into account that varus angulation decreases if the nails are inserted less laterally. We agree with this information and it is clearly reflected in the development of our study.

We believe it is extremely important to highlight again the results obtained regarding the medial entry point, because several authors, including Tejwani et al.,[20] described that a medial entry point exaggerates the valgus deformity, a situation that occurred throughout our study, but with the variable that 25% of patients with a medial entry point did not develop any misalignment, a fact that should be taken into account by orthopedic surgeons who routinely perform this procedure.

CONCLUSIONS

We can affirm that the entry point of intramedullary nailing is directly and continuously related to the postsurgical alignment of tibial shaft fractures treated with this procedure. We found that the recommended entry point for the intramedullary nail is the central one, due to the fact that it experiences fewer postsurgical deviations in the coronal plane. Regarding the two remaining entry points, it should be noted that 25% of the fractures with a medial entry point did not have any deviation, while all of those with a lateral entry point had some defect in the final alignment.

Conflict of interest: The authors declare no conflicts of interest.

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